12-1999

Nutrient and Sediment Loss from the Watersheds of Orleans County Year 2: Johnson, Oak Orchard and Sandy Creek Watersheds. June 1998 - May 1999

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NUTRIENT and SEDIMENT LOSS FROM WATERSHEDS of ORLEANS COUNTY – YEAR 2

Johnson, Oak Orchard and Sandy Creek Watersheds

June 1998 to May 1999

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Prepared for the
Orleans County Soil and Water Conservation District
Albion, NY

December 1999

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SUMMARY

1. **Oak Orchard, Johnson and Sandy Creeks were intensely monitored for a second consecutive year (1 June 1998 to 31 May 1999).** The sampling design included automated daily gauging of stream depths and automated event sampling stations allowing accurate measurement of discharge and nutrient and sediment loss from the watersheds during both event and nonevent conditions. Discharge and concentrations of nitrate, total phosphorus, sodium, total suspended solids, and total Kjeldahl nitrogen were measured and converted into the amount of material lost from each watershed.

2. **Annual precipitation was more that 7 inches below normal (38.10") for the sampling period.** The National Weather Service recorded 31.02 inches of liquid precipitation at its office in Buffalo, NY from June 1998 to May 1999. There were only two days that had greater than 1.0 inches of precipitation versus seven days during the last reporting period.

3. **Compared to the other watersheds in New York State, Oak Orchard Creek, Johnson Creek and Sandy Creek are moderately polluted on an areal basis.** They are not as pristine as completely forested watersheds or as polluted as streams receiving direct discharge from a sewage treatment plant. These results are tempered with a fair amount of caution. The two study years were extremely dry, especially during the summer, and may not be representative of conditions during a period of normal rainfall.

4. **Large amounts of an essential nutrient, phosphorus, was lost from the watershed.** Sixty two tons of phosphorus (56,056 kg) were lost during the period from 1 June 1998 to 31 May 1999 from the combined Oak Orchard Creek, Johnson Creek and Sandy Creek watersheds. On a daily basis, approximately 113 pounds of phosphorus is lost per day from the three major watersheds in Orleans County. Total phosphorus losses in descending order were Oak Orchard (106 kg/d), Johnson (30 kg/d) and Sandy (18 kg/d). A similar pattern occurred when the total phosphorus loadings were put on an areal basis.

5. **Soil loss was excessive, especially from Oak Orchard Creek, during meterological events.** 6,800 metric tons of soil was lost from these three watersheds during the study period. Over 57% (3900 metric tons) of this soil lost was from the Oak Orchard watershed. Johnson Creek (87.7%) and Sandy Creek (74.9%) lost the majority of soil (total suspended solids) during precipitation events. These high losses from the watershed during precipitation events strongly suggest erosive losses from agriculture - although the possibility of bank erosion of streams can not be ruled out.

6. **Loss of nitrogen was greatest from the Oak Orchard Creek watershed.** Oak Orchard Creek (nitrate: 1,683 kg N/d; TKN: 763 kg N/L) had more than four times the nitrate and TKN loading rate as Johnson Creek (nitrate: 418 kg N/d; TKN: 174 kg N/L) and more than eight times the nitrate and TKN loading of Sandy Creek (nitrate: 198 kg N/d; TKN: 91 kg N/d).

7. **Of the three watersheds studied, Oak Orchard Creek had the greatest loss of soil (TSS), total phosphorus, total kjeldahl nitrogen and nitrate on both an annual basis and an areal basis.** By areal basis, we mean that the losses of materials from the watershed are normalized to consider the different areas of the watershed.

RECOMMENDATIONS

1. The intensive tributary monitoring should be discontinued at the present time. The two years of data represent a strong baseline data set of discharge and loading information – although for a dry period. The data can be used for prioritizing watersheds of concern and as a benchmark for evaluating the success of any future remediation efforts.

2. Intensive monitoring should be reinstated during "wetter" conditions. The data presented are accurate but represent losses from the watershed during a dry period. Based on our experience and the work of others, losses of materials are likely to be considerably higher during "wet" and even "normal " years of precipitation.

3. Intensive monitoring should be reinstated either after a period of pollution source identification and remediation.

4. Stressed Stream Analysis or "segment analysis" should be initiated for the Oak Orchard watershed to identify sources of pollution. The second year of our study clearly indicates that the Oak Orchard Creek watershed should be the priority watershed for clean-up. The focus of our work now becomes what is the cause of the high loss of nutrients and soils from the Oak Orchard watershed?

5. An effort should be initiated to establish a cooperative agreement with Genesee County to fund a large scale Stressed Stream Analysis for the entire Oak Orchard Creek that encompasses both counties. Due to the size of the watershed and budget constraints, only one northern portion of the watershed will be studied initially.

6. Consideration should be given to developing a mechanism to initiate remedial action plans and best management plans in the county. Our work will identify point and nonpoint sources of nutrients and soil having the largest impact on the water quality of the streams. With the data that are being gathered, opportunities exist to remediate the watershed and improve water quality in the affected streams. The question becomes how does the Soil and Water Conservation District move into a "prevent" mode? Perhaps the best place to start is to have the Director of the Soil and Water Conservation District visit other locations to determine how they implemented plans to improve water quality. We could provide contact names, if requested.

INTRODUCTION

Freshwater resources have historically played an instrumental role in community development and economic sustainability. Orleans County is not an exception. The water resources in the County play an important role in the economy, have aesthetic value and provide diverse opportunities for those who enjoy the resource directly. A major thrust of the County's tourism industry is predicated on the availability of high quality water resources and angling opportunities in nearshore Lake Ontario and its tributaries. In addition, a major goal of the U.S. Fish and Wildlife is the restoration of stream habitat that would allow the natural reproduction of native Lake Ontario fish species, such as the Atlantic salmon in Johnson Creek. Needless to say, agriculture also has a major economic impact in Orleans County and loss of important resources, such as soil and nutrients, from a watershed is of concern to the land owner and the Soil and Water Conservation District. Remediation and protection of these resources depends largely on the identification of both the cause and effect of elements likely to reduce their economic and social value.

In recognition of the need to acquire a uniform, organized approach to addressing surface water degradation and given the diverse nature of non-point sources of pollution, the Soil and Water Conservation District has recently formed a committee whose specific task is to address water quality issues. Since the reduction of non-point source pollution is likely to occur through the implementation of Best Management Practices (BMP's) and changes in land use regulations, this committee provides the necessary foundation for these changes to occur. This committee has become known as the Orleans County Water Quality Coordinating Committee (WQCC). With the combined expertise of the Water Quality Coordinating Committee and the availability of actual field data, progress towards healthier freshwater resources is underway. A recommendation of the WQCC was to move forward in prioritizing the major tributaries in terms of high nutrient losses from the watershed.

The objectives of Orleans County's program include:

1. Determination of the status of Orleans County's primary surface waters and observe changes over time;
2. Documentation of what types and amounts of nutrients may be adversely impacting water quality and the conditions which generate them;
3. Determination of what urban, rural, industrial and agricultural practices within a watershed may be impacting water quality;
4. Development of a technical database for informed water quality management decisions; and,
5. Assessment of the feasibility and effectiveness of potential control measures likely to be used to reduce non-point and point sources of pollution.

Determination of sources and magnitude of soil and nutrient losses from a watershed is prerequisite to remedial action and essential to making cost-effective land management decisions as it reduces the likelihood of costly miscalculations based on the assumption of soil and nutrient sources and modeling rather than their actual identification. We have found that this process enhances the ability of concerned groups to obtain external funding for demonstration and remedial projects.

Starting in June of 1997, intensive, automated water quality monitoring on Johnson Creek, Oak Orchard Creek and Sandy Creek was initiated. Monitoring has continued for a second consecutive year. The two-year data base on three major tributaries in Orleans County represents a strong benchmark of discharge and loading that can by used to measure the success of future remediation efforts.

DEFINITIONS

Total Phosphorus- A measure of all forms of the element phosphorus. Phosphorus is an element required for plant growth on land or in water. In lakes, phosphorus is often the limiting factor of phytoplankton growth and is the cause of eutrophication, or overproduction, of lakes. Phosphorus may enter a watershed in soluble or organic form from several sources including sewage, heavy-duty detergents, fertilizer and agricultural waste. Some forms of phosphorus are more available to and cause more immediate activity in plants.

Soluble Reactive Phosphorus- A measure of the most available and active form of phosphorus.

Nitrates + Nitrites- A measure of the soluble forms of nitrogen used readily by plants for growth. Sources of nitrates in the environment are many and include barnyard waste and fertilizer.

Total Kjeldahl Nitrogen- The Kjeldahl method is a convenient method of analysis for nitrogen but cannot be used for all types of nitrogen compounds. It is, however, a good measure of organic nitrogen, including ammonia. Manure, for example, contains a large amount of organic nitrogen.

Sodium- A measure of the mineral, most commonly found as sodium chloride (NaCl), dissolved in water. NaCl naturally occurs in deep layers of local bedrock. Mined, it is stored and spread as a de-icing agent on roads and other pavements.

Total Suspended Solids - A measure of the loss of soil and other materials suspended in the water from a watershed. Water-borne sediments act as an indicator, facilitator and agent of pollution. As an indicator, they add color to the water. As a facilitator, sediments often carry other pollutants, such as nutrients and toxic substances. As an agent, sediments smother organisms and clog pore spaces used by some species for spawning.

METHODS

General:

Personnel from the Orleans County Soil and Water Conservation District collected stream water samples on Oak Orchard, Johnson and Sandy Creeks from 1 June 1998 to 31 May 1999. The three monitoring sites were previously described in the last report (Makarewicz and Lewis 1998). Oak Orchard Creek and Johnson Creek stream levels were monitored continuously with an American Sigma flow meter linked to an American Sigma sequential sampler which allowed hourly stream sampling during precipitation events. Sandy Creek was continuously monitored with an ISCO flow meter and automatic water sampler set up in a similar configuration. The rise in the stream level that signified an event and subsequently triggered the automatic samplers to begin sampling are as follows:

Sandy Creek - a stream level rise of 0.2 feet above the weekly ambient level;

Oak Orchard and Johnson Creeks - a rise of 1.5 inch per hour.

Weekly baseline and event samples were transported to SUNY Brockport for chemical analysis for total phosphorus (TP), total Kjeldahl nitrogen (TKN), nitrate + nitrite, sodium and total suspended solids (TSS) (see detailed analytical methods below).

Nutrient and suspended solids losses from the watershed were calculated by multiplying the discharge by the concentration of the nutrient or suspended solids from the appropriate water sample. Stream discharge was manually divided into "baseline" and hydrological "event" conditions (elevated discharge). Event losses from the watershed or loadings to Lake Ontario were calculated using the event chemistry values.

All sampling bottles were pre-coded so as to ensure exact identification of the particular sample. All filtration units and other processing apparatus were cleaned routinely with phosphate-free RBS. Containers were rinsed prior to sample collection with the water being collected. In general, all procedures followed EPA standard methods (EPA 1979) or Standard Methods for the Analysis of Water and Wastewater (APHA 1999). Sample water for dissolved nutrient analysis (nitrate + nitrite) was filtered immediately with 0.45 μm MCI Magma Nylon 66 membrane filters and held at 4°C until analysis.

Water Chemistry:

Nitrate + Nitrite: Dissolved nitrate + nitrite nitrogen analyses were performed by the automated (Technicon Autoanalyser) cadmium reduction method (EPA 1979, APHA 1999).

Sodium: Sodium was determined by atomic absorption spectrophotometry (Perkin-Elmer 3030) (APHA 1999).

Total Phosphorus: The persulfate digestion procedure was used prior to analysis by the automated (Technicon autoanalyser) colorimetric ascorbic acid method (APHA 1999).

Total Kjeldahl Nitrogen: Analysis was performed using a modification of the Technicon Industrial Method 329-74W/B. The following modifications were performed:

- In the sodium salicylate-sodium nitroprusside solution, sodium nitroferri-cyanide (0.4g) replaced the concentrated nitroprusside stock solution.
- The reservoir of the autoanalyser was filled with 0.2M H_2SO_4 instead of distilled water.
- Other reagents were made fresh prior to each analysis.

Total Suspended Solids: APHA (1999) Method 2540D was employed for this analysis.

Physical Measurements:

Stream Velocity: Stream velocity was measured at equally spaced locations in the cement channel of a bridge over the streams with a Gurley flow meter (Chow 1964). A regression equation was calculated for velocity versus stream height and is presented in Makarewicz and Lewis (1998).

Stream Height: Hourly readings of the stream level were measured using an American Sigma or ISCO flow meter equipped with a bubbler sensor or pressure transducer. Creek depths, as measured by the flow meters, were manually calibrated weekly. Stream cross-sectional area for various stream heights were calculated by planimetry after measuring the cross-sectional dimensions of the cement channel bridges. A polynomial was fit to the values for selected stream area using Sigma Plot (Jandel Scientific) and can be found in last year's report (Makarewicz and Lewis 1998).

Watershed Area: The watershed area of Oak Orchard, Johnson and Sandy Creeks was revised by the Orleans County Soil and Water Conservation District. The delineation was performed on topographic maps and quantified by planimetry. The watershed area used in this report is the area upstream from the monitoring stations (Makarewicz and Lewis 1998).

Discharge and Losses from the Watershed (Loading):

Hourly stream level readings (stage height) of Oak Orchard, Johnson and Sandy Creeks were converted to discharge by a second order polynomial rating curve (Makarewicz and Lewis 1998). For the calculation of nutrient losses from the watershed, event losses were calculated by adding up hourly discharge for both the rising and falling limbs and multiplying them by their respective water chemistry concentrations. During nonevent periods, hourly discharge was summarized into a daily discharge and multiplied by that period's water chemistry concentrations. If a hydrologic event occurred during the week, weekly losses from the watershed were calculated by adding together the event and nonevent losses for the period to obtain total loading to Lake Ontario or total weekly losses from the watershed (event plus nonevent).

QUALITY ASSURANCE

Internal Quality Control: Multiple sample control charts (APHA 1999) were constructed for each parameter analyzed, except total suspended solids. A prepared quality control solution was placed in the analysis stream for each sampling date. If the control solution was beyond the set limits of the control chart, corrective action was taken and the samples re-run.

External Quality Control: The Water Chemistry Laboratory at SUNY Brockport is certified through the New York State Department of Health's Environmental Laboratory Approval Program (ELAP - # 11439). This program includes biannual proficiency audits, annual inspections and good laboratory practices documentation of all samples, reagents and equipment. Table 1 is a summary of our last proficiency audit.

RESULTS and DISCUSSION

DISCHARGE

The mean daily discharge values (m^3/day) for the 1 June 1998 to 31 May 1999 period were in descending order: Oak Orchard Creek (956,238); Johnson Creek (235,505) and Sandy Creek (117,174) (Table 2a, Appendices 1-3). The majority of the discharge of water from the watershed occurred during the winter seasons (Oak Orchard 45.8%, Johnson 46.1%, Sandy 44.6%) (Tables 3-5). Event conditions accounted for 10.8%, 24.2% and 26.5% of the annual discharge of Oak Orchard, Johnson and Sandy Creeks, respectively (Table 6). The percent of event discharge decreased this year versus last due to a decrease in precipitation resulting in an abnormally dry year. Annual precipitation was more that 7 inches below normal for the sampling period. The National Weather Service recorded 31.02 inches of liquid precipitation at its office in Buffalo, NY during June 1998 to May 1999; the normal mean annual precipitation is 38.10 inches. There were two days that had greater than 1.0 inches of precipitation versus seven days during the last reporting period.

The relatively low percentage of event discharge attributed to Oak Orchard Creek is probably due to Glenwood Lake in Medina, which acts as a reservoir storing water during events and releasing it later slowly during baseflow.

CONCENTRATION

Concentrations of total phosphorus, sodium and nitrate in stream water were highest in Sandy Creek. Total suspended solids and total Kjeldahl nitrogen levels were highest in Oak Orchard Creek. During event conditions, total phosphorus, total Kjeldahl nitrogen and total suspended solids concentrations increased in all three creeks studied (Table 7). Sodium concentrations are reduced in some creeks as some dilution occurs during periods of heavy precipitation.

<u>Sodium (Table 7):</u>

Higher values of sodium usually reflect the use of deicing salt in the watershed during the winter and spring seasons. Baseline or nonevent concentrations of sodium were highest in Sandy Creek (34.29 mg/L), followed by Johnson Creek (31.38 mg/L) and Oak Orchard Creek (26.15 mg/L). Event concentration of sodium did not change significantly as the sodium is diluted by the larger volume of water.

<u>Total Suspended Solids (Table 7):</u>

Total suspended solid concentrations in stream water generally reflect the amount of materials (e.g., soils) being lost from a watershed. Total suspended solids concentrations were under 10 mg/L for all three streams during non-event conditions. Total suspended solids concentrations increased significantly during events as the increased water flowing over the landscape carries more material.

<u>Total Phosphorus (Table 7):</u>

Phosphorus is an element required for plant growth whether on land or in the water. In lakes, phosphorus is often the limiting factor of phytoplankton growth and is the cause of eutrophication, or overproduction of lakes. Phosphorus may enter a stream from the watershed as a result of sewage disposal, heavy fertilizer use for lawns or agriculture and through erosion of soil. Watersheds that have streams with high phosphorus concentrations are potentially the cause of increased phytoplankton and macrophyte (weed) production in lakes. Sandy Creek (123.7 μg P/L), Oak Orchard Creek (103.5 μg P/L) and Johnson Creek (95.8 μg P/L) had relatively high nonevent concentrations of total phosphorus when compared to other creeks in western and central New York State (Table 8).

Total phosphorus concentrations increased significantly during runoff events, with Johnson and Sandy Creeks showing the largest increases (Table 7). Total phosphorus in Oak Orchard Creek did not increase as much as the other streams during events, probably due to Glenwood Lake in Medina which acts as a buffer between the upstream and downstream regions by acting as a settling basin for particulate materials in the stream.

Nitrate and Total Kjeldahl Nitrogen (TKN) (Table 7):
Nitrate is found in fertilizer, while total kjeldahl nitrogen roughly represents the organic nitrogen present. Organic nitrogen would occur from sources such as sewage and animal manure. Baseline nitrate concentrations were highest in Sandy Creek (1.50 mg N/L), followed by Johnson Creek (1.30 mg N/L) and Oak Orchard Creek (1.29 mg N/L). The nitrate concentration did not increase significantly during events in Sandy Creek (2%) but nearly doubled during events in both Johnson (189%>) and Oak Orchard Creeks (162%>).

The baseline concentration of TKN were nearly identical for the three tributaries (range 618 to 667 μg N/L). Total Kjeldahl nitrogen increased 71% in Sandy Creek, 63% in Oak Orchard Creek and 57% in Johnson Creek during events.

LOSS OF MATERIALS AND NUTRIENTS FROM THE WATERSHED

Although concentration of pollutants are a useful piece of information in evaluating streams, these data are limited and may lead to an inaccurate conclusion. The total loss of a pollutant from a watershed or loading to down-stream systems is a better measurement of a watershed's impact because it considers the volume of water in addition to the concentration of the nutrient in that water. A stream with a high concentration of a nutrient but a low discharge will have less of an impact on downstream systems than a stream with high discharge and a moderate concentration of a nutrient.

Tables 3, 4 and 5 present the annual loss of total phosphorus, total Kjeldahl nitrogen, nitrate, total suspended solids and sodium from the respective watersheds for the period 1 June 1998 to 31 May 1999. The data presented is based on continuous discharge measured at each creek and thus reflects both high discharge caused by precipitation events and baseflow (nonevent) periods. The event data presented is a result of only those events that were automatically triggered (see methods) by the continuous discharge recorder located on the creeks.

Average Daily Losses During Events and Baseline Conditions:
Each bar graph in this series of graphs (Figs. 1-6) represents the nutrient or material losses from a tributary and its associated watershed normalized by the size of the watershed to allow direct comparison of each tributary - sometimes termed areal loading. The red bar (darker bar) is average daily event loading; the green bar (lighter bar) represents the average daily baseline or non-event loading to Lake Ontario from the various Orleans County watersheds. Baseline losses compared to losses from the watershed during events are generally low when considered on a per day basis. Daily losses from the watersheds during events are two to ten times the baseline losses

for total suspended solids (soils), total phosphorus and total Kjeldahl nitrogen.

Annual Losses from the Watersheds (Fig. 7):

Sodium:

Sodium is a major constituent of deicing salt and is often washed off watersheds after application. As expected, major losses of sodium from the watershed occurred during the study period. Oak Orchard Creek, which has twice the watershed area and undoubtedly more roads than Johnson and the Sandy Creek watersheds, had over twice the sodium loss of the two other watersheds (Table 2a). Not surprisingly, more sodium is lost from the watersheds during the winter season - a period of high application of deicing salts to roads (Oak Orchard 54.0%, Johnson 51.1% and Sandy 55.3%)(Tables 3-5).

Total Suspended Solids (TSS):

The loss of suspended solids from a watershed is a measurement of loss of soil or erosion from a watershed. The annual loss of soils from the three major watersheds in Orleans County decreased significantly when compared to the previous year (6,800 metric tons compared to 10,000 metric tons). This is due to the decrease in the number and magnitude of events during this dry year. The percent of annual loss of TSS that occurred during events decrease in two of the three creeks (Johnson 88% to 58%; Sandy 75% to 83%; Oak Orchard 46% to 20%) (Table 7, Makarewicz and Lewis 1998).

Oak Orchard lost over 3900 metric tons during the sampling period. Johnson Creek (57.9%) and Sandy Creek (83.5%) lost the majority of TSS during precipitation events (Table 6). These high losses from the watershed during precipitation events strongly suggest erosive losses from agriculture - although the possibility of bank erosion of streams can not be ruled out. Oak Orchard Creek lost only 46.2 % of TSS during precipitation events. On an areal basis, Oak Orchard Creek lost the most suspended solids at 293 g/ha/day (Fig. 7).

Nutrients:

Annually, Oak Orchard Creek had the greatest loss of total phosphorus, total Kjeldahl nitrogen and nitrate on both an annual basis and an areal basis (Table 2a). Total phosphorus losses in descending order were Oak Orchard (106 kg/d), Johnson (30 kg/d) and Sandy (18 kg/d). A similar pattern occurred when the total phosphorus loadings were put on an areal basis (Fig. 7).
Oak Orchard Creek (nitrate: 1,683 kg N/d; TKN: 763 kg N/L) had more than four times the nitrate and TKN loading rate as Johnson Creek (nitrate: 418 kg N/d; TKN: 174 kg N/L) and more than eight times the nitrate and TKN loading of Sandy Creek (nitrate: 198 kg N/d; TKN: 91 kg N/d) (Table 2a). In terms of phosphorus, 62 tons (56,056 kg) were lost during the period from 1 June 1998 to 31 May 1999 from the combined Oak Orchard Creek, Johnson Creek and Sandy Creek watersheds. This averages out to 113 pounds of phosphorus lost per day from the three major watersheds in Orleans County.

COMPARISON TO OTHER WATERSHEDS

The various creeks of the Irondequoit Bay watershed (Monroe County, NY.) have been identified as grossly polluted prior to remedial action (O'Brien and Gere 1983). Similarly, Northrup Creek (central Monroe County), which receives effluent from a sewage treatment plant, is known to be polluted and to possess a higher loading of phosphorus than creeks in the

Irondequoit Bay watershed (Makarewicz 1988). A comparison of Orleans County tributaries to other creeks in western and central New York State is instructive in identifying the relative condition of creeks (Table 9). Compared to the other watersheds, on an areal basis, Oak Orchard Creek, Johnson Creek and Sandy Creek are moderately impacted. They are not as pristine as completely forested watersheds nor as polluted as streams receiving direct discharge from a sewage treatment plant. Each Orleans County stream will have point and/or non-point sources of pollution in their respective watersheds that should be identified and the problems addressed. Segment analysis or stress stream analysis is a process that can identify both point and non-point sources within a watershed.

BEST MANAGEMENT PRACTICES

Identified point and non-point sources of nutrients and solids can be remediated using Best Management Practices (BMP). Whether or not management practices include a reduction of cropland or fertilization, control of water movement can be a means of significantly reducing non-point source pollution. Since water must come in contact with the nutrient source and then be transported to the surface (or subsurface) water body, the nutrients in water bodies are functions of soil fertility and quantities of transporting water. Management practices which reduce surface runoff have been shown to decrease dramatically the magnitudes of sediment and chemical losses from land areas (Haith 1975).

Haith (1975) and the NYSDEC (1986) recommend use of buffer strips of forest or grass between the pollutant source and a stream to intercept the runoff, resulting in removal by deposition or filtering by the vegetative cover. Other cropland management practices include diversions, terraces contour cropping, strip cropping, waterways, minimum and no tillage. Livestock operation controls include barnyard runoff management, manure storage facilities and livestock exclusion from woodlands.

Urban and rural management applications include critical area stabilization, shoreline protection and settling basins. Urban area best management practices include leaf collection, street sweeping and infiltration systems. The relatively few days of high runoff required to export much of the annual water and nutrients from the Orleans County watersheds implies the necessity of management practices designed to deal with the large volumes of water involved during intense runoff events. Changes in cropping and soil conservation practices, decreases in impervious services and provision of buffer areas along surface waterways will result in predictable changes in runoff quantities and qualities and hence non-point source pollution (Haith 1975).

ACKNOWLEDGEMENTS

Our job was made much easier and enjoyable with the help of David Reckahn, Alan Boekhout and the Orleans County Water Quality Committee. They assisted with collecting samples, providing field information, and infected us with their concern for the water resources of Orleans County. We also wish to thank Roger Ward, Betsy Damaske, Daina Beckstrand, Tom Krueger, Marshall Haas, Heather Halbritter and Stephanie Mahan for their assistance in the field and laboratory work.

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Table 1. Results of the semi-annual New York State Environmental Laboratory Assurance Program (ELAP Lab # 11439, SUNY Brockport) Non-Potable Water Chemistry Proficiency Test, July 1999. Score Definition: 4 (Highest) = Satisfactory, 3 = Marginal, 2 = Poor, 1 = Unsatisfactory.

Analyte	Mean/Target	Result	Score
Residue			
Solids, Total Suspended	18.3 mg/L	18.2 mg/L	4
Hydrogen Ion (pH)			
Hydrogen Ion (pH)	6.00	5.96	4
Organic Nutrients			
Kjeldahl Nitrogen, Total	14.70 mg/L	15.60 mg/L	4
Phosphorus, Total	1.56 mg/L	1.59 mg/L	4
Total Alkalinity			
Alkalinity	94.60 mg $CaCO_3$/L	98.32 mg $CaCO_3$/L	4
Inorganic Nutrients			
Nitrate (as N)	14.80 mg/L as N	13.33 mg/L as N	4
Orthophosphate (as P)	0.914 mg/L as P	0.920 mg/L as P	4
Minerals			
Chloride	180.0 mg/L	183.2 mg/L	4
Wastewater Metals I and II			
Calcium, Total	20.30 mg/L	19.54 mg/L	4
Magnesium, Total	13.00 mg/L	14.22 mg/L	4
Potassium, Total	5.03 mg/L	5.29 mg/L	4
Sodium, Total	35.70 mg/L	36.68 mg/L	4

Table 2. Average daily loadings of selected parameters from Oak Orchard, Johnson and Sandy Creeks for the period 1 June 1998 to 31 May 1999. TP = total phosphorus, TSS = total suspended solids and TKN = total Kjeldahl nitrogen.

A. **Baseline + Event**

	Discharge (m^3/d)	**TP (kg/d)**	**Nitrate (kg/d)**	**Sodium (kg/d)**	**TSS (kg/d)**	**TKN (kg/d)**
Oak Orchard	956,238	106	1,683	25,077	10,819	763
Johnson Creek	235,505	30	418	6,531	3,450	174
Sandy Creek	117,174	18	198	3,668	4,332	91
	Discharge (m^3/ha/d)	**TP (gm/ha/d)**	**Nitrate (gm/ha/d)**	**Sodium (gm/ha/d)**	**TSS (gm/ha/d)**	**TKN (gm/ha/d)**
Oak Orchard	25.85	2.86	45.51	677.95	292.50	20.63
Johnson Creek	9.22	1.17	16.38	255.80	135.13	6.80
Sandy Creek	5.08	0.77	8.59	159.08	187.91	3.93

B. **Baseline**

	Discharge (m^3/d)	**TP (kg/d)**	**Nitrate (kg/d)**	**Sodium (kg/d)**	**TSS (kg/d)**	**TKN (kg/d)**
Oak Orchard	852,758	92	1,278	21,797	8,665	645
Johnson Creek	178,606	15	264	4,962	1,452	115
Sandy Creek	86,147	9	144	2,790	716	54
	Discharge (m^3/ha/d)	**TP (gm/ha/d)**	**Nitrate (gm/ha/d)**	**Sodium (gm/ha/d)**	**TSS (gm/ha/d)**	**TKN (gm/ha/d)**
Oak Orchard	23.05	2.50	34.54	589.28	234.27	17.45
Johnson Creek	7.00	0.59	10.33	194.37	56.88	4.52
Sandy Creek	3.74	0.39	6.24	121.00	31.04	2.33

C. **Event**

	Discharge (m^3/d)	**TP (kg/d)**	**Nitrate (kg/d)**	**Sodium (kg/d)**	**TSS (kg/d)**	**TKN (kg/d)**
Oak Orchard	103,480	14	406	3,280	2,154	118
Johnson Creek	56,899	15	154	1,568	1,998	58
Sandy Creek	31,026	9	54	878	3,617	37
	Discharge (m^3/ha/d)	**TP (gm/ha/d)**	**Nitrate (gm/ha/d)**	**Sodium (gm/ha/d)**	**TSS (gm/ha/d)**	**TKN (gm/ha/d)**
Oak Orchard	2.80	0.37	10.97	88.67	58.24	3.18
Johnson Creek	2.23	0.57	6.05	61.43	78.25	2.28
Sandy Creek	1.35	0.38	2.36	38.08	156.87	1.60

Table 3. Annual loss of material and nutrients from the Sandy Creek watershed. TP = total phosphorus, TSS = total suspended solids, TKN = total Kjeldahl nitrogen.

	Discharge (m^3)	TP (kg)	Nitrate (kg)	Sodium (kg)	TSS (kg)	TKN (kg)
Spring	7,891,147	720	8,108	247,674	95,948	3,727
Summer	6,386,524	1,634	8,786	140,697	362,174	5,819
Fall	9,413,508	921	9,150	209,582	67,458	4,617
Winter	19,077,220	3,221	46,275	740,767	1,055,778	18,910
Annual Total	42,768,399	6,496	72,319	1,338,720	1,581,358	33,073
% Spring	18.5	11.1	11.2	18.5	6.1	11.3
%Summer	14.9	25.2	12.1	10.5	22.9	17.6
%Fall	22.0	14.2	12.7	15.7	4.3	14.0
%Winter	44.6	49.6	64.0	55.3	66.8	57.2

Table 4. Annual loss of material and nutrients from the Johnson Creek watershed. TP = total phosphorus, TSS = total suspended solids, TKN = total Kjeldahl nitrogen.

	Discharge (m^3)	TP (kg)	Nitrate (kg)	Sodium (kg)	TSS (kg)	TKN (kg)
Spring	20,851,070	1,607	15,574	632,882	210,193	13,738
Summer	12,919,337	1,600	12,955	266,992	210,707	7,547
Fall	12,592,820	952	9,347	266,932	46,233	6,606
Winter	39,595,982	6,722	114,783	1,216,869	792,077	35,517
Annual Total	85,959,209	10,881	152,659	2,383,675	1,259,210	63,408
% Spring	24.3	14.8	10.2	26.6	16.7	21.7
%Summer	15.0	14.7	8.5	11.2	16.7	11.9
%Fall	14.6	8.7	6.1	11.2	3.7	10.4
%Winter	46.1	61.8	75.2	51.1	62.9	56.0

Table 5. Annual loss of material and nutrients from the Oak Orchard Creek watershed. TP = total phosphorus, TSS = total suspended solids, TKN = total Kjeldahl nitrogen.

	Discharge (m^3)	TP (kg)	Nitrate (kg)	Sodium (kg)	TSS (kg)	TKN (kg)
Spring	67,453,995	6,591	58,300	2,084,195	1,056,591	40,510
Summer	75,981,606	9,108	64,861	1,421,347	1,047,095	42,449
Fall	45,567,120	2,717	33,267	701,530	257,155	19,948
Winter	160,024,068	20,264	457,966	4,945,887	1,588,248	175,609
Annual Total	349,026,789	38,680	614,394	9,152,959	3,949,089	278,516
% Spring	19.3	17.0	9.5	22.8	26.8	14.5
%Summer	21.8	23.5	10.6	15.5	26.5	15.2
%Fall	13.1	7.0	5.4	7.7	6.5	7.2
%Winter	45.8	52.4	74.5	54.0	40.2	63.1

Table 6. Percent baseline and event loading values for selected parameters for Oak Orchard, Johnson and Sandy Creeks for the period 1 June 1998 to 31 May 1999. TP = total phosphorus, TSS = total suspended solids and TKN = total Kjeldahl nitrogen.

Percent Baseline

	Discharge (%)	TP (%)	Nitrate (%)	Sodium (%)	TSS (%)	TKN (%)
Oak Orchard	89.2	87.2	75.9	86.9	80.1	84.6
Johnson Creek	75.8	50.9	63.1	76.0	42.1	66.4
Sandy Creek	73.5	50.8	72.6	76.1	16.5	59.2

Percent Event

	Discharge (%)	TP (%)	Nitrate (%)	Sodium (%)	TSS (%)	TKN (%)
Oak Orchard	10.8	12.8	24.1	13.1	19.9	15.4
Johnson Creek	24.2	49.1	36.9	24.0	57.9	33.6
Sandy Creek	26.5	49.2	27.4	23.9	83.5	40.8

Table 7. Comparison of baseline and event water chemistry concentrations for the period 1 June 1998 to 31 May 1999 in Oak Orchard, Johnson and Sandy Creeks. Values are the average ± standard error. The range is in parenthesis.

	Oak Orchard Creek		Johnson Creek		Sandy Creek	
	Baseline	Event	Baseline	Event	Baseline	Event
Total phosphorus (µg P/L)	103.5 ± 5.4 (33.5 – 212.0)	145.4 ± 16.9	95.8 ± 5.0 (34.3 – 197.0)	219.4 ± 42.0	123.7 ± 8.9 (26.8 – 313.4)	341.7 ± 63.7
Nitrate + Nitrite (mg N/L)	1.29 ± 0.13 (0.27 – 4.38)	2.10 ± 0.87	1.30 ± 0.13 (0.30 – 4.42)	2.46 ± 0.47	1.50 ± 0.16 (0.21 – 4.70)	1.53 ± 0.24
Total Suspended Solids (mg/L)	9.9 ± 1.7 (0.1 – 78.0)	25.4 ± 9.8	7.9 ± 0.9 (0.1 – 29.5)	79.2 ± 40.2	9.0 ± 1.6 (0.2 – 61.2)	119.6 ± 15.5
Total Kjeldahl Nitrogen (µg N/L)	667 ± 38 (80 – 1250)	1087 ± 34	618 ± 33 (160 – 1530)	969 ± 109	638 ± 36 (230 – 1250)	1090 ± 112
Sodium (mg/L)	26.15 ± 1.71 (14.47 – 58.98)	36.87 ± 4.85	31.38 ± 2.34 (15.77 – 90.8)	26.31 ± 3.46	34.29 ± 2.28 (1.65 – 77.21)	27.34 ± 2.12
Watershed area (ha)	36,989		25,530		23,056	

Table 8. Nonevent (baseline) total phosphorus concentrations and watershed areas from creeks in central and western New York. Data is from Makarewicz 1988, Makarewicz and Lewis 1992, 1996, 1998, 1998a, Makarewicz *et al.* 1991.

Creek/Watershed	**Total Phosphorus (µg P/L)**	**Watershed Area (ha)**	**Land Use**
Canandaigua Lake Watershed 1997			
Fall Brook	19.4	1343	Agriculture /suburban
Deep Run Gully	7.4	525	Agriculture
Vine Valley	28.4	1115	Agriculture
Clark Gully	9.1	325	Forested
Naples Creek	5.5	8143	Agriculture / Suburban
Sucker Brook	97.5	1759	Urban / Agriculture
Seneca Point	94.8	1048	
Oswego County 1997			
Sheldon	92.0	1357	Muckland
Summerville	108.1	409	Suburban
Ley	270.8	632	Muckland / Agriculture
Wayne County 1991-92			
Sodus	46.3	3065	Agriculture
Wolcott	115.6	4416	Agriculture
Second	31.3	2610	
Orleans County 1997-98			
Oak Orchard	126.4	36989	Agriculture
Johnson	88.3	25530	Agriculture
Sandy	96.9	23056	Agriculture / Suburban
Orleans County 1998-99			
Oak Orchard	103.5	36989	Agriculture
Johnson	95.8	25530	Agriculture
Sandy	123.7	23056	Agriculture / Suburban
Seneca County 1990-94			
Kendig	143.0	5149	Agriculture
Livingston County 1990-91			
Hanna's	74.6	718	Agriculture / Suburban
Conesus Inlet	28.2	4475	Wetlands / Agriculture
South McMillan	30.6	2687	Agriculture
Monroe County 1987-88			
Upper Northrup	68.60	1049	Suburban
Lower Northrup	263.60	1862	Suburban/Sewage Plant

Table 9. Comparison of phosphorus loading in subbasins of the Irondequoit Bay watershed, other Monroe County creeks, tributaries of Sodus and Port Bays, and Lake Neatahwanta tributaries. Irondequoit basin data are from 1980-81 (O'Brien and Gere 1983). Data from other Monroe County creeks are from 1987-88 (Makarewicz 1988). Wayne County creek data from 1991-93 are from Makarewicz et al. 1991, 1992, 1993, 1998 and 1998a, Makarewicz and Lewis 1998. All data is for an annual period (i.e., mean annual daily loading).

Subbasin or Creek	**Land Use**	**Annual Total Phosphorus Loading (g P/ha/d)**	
Sucker Brook	Agriculture/ Urban	7.66	
Irondequoit Creek at Browncroft Blvd. 1975-77 (pre-diversion)	Several Sewage Plants	5.60	
1978-79(post-diversion)		2.00	
Larkin	Suburban	0.70	
Buttonwood	Suburban	1.58	
Lower Northrup	Sewage Plant	6.64	
Upper Northrup	Urban	3.23	
First	Forested	0.11	
Clark	Forested	0.22	
Sodus East	Agriculture	8.57	
Wolcott	Agriculture	5.01	
Bobolink	Forested	0.02	
Sheldon	Muckland	27.41	
Summerville	Suburban	5.47	
		1997-98	1998-99
Oak Orchard		3.48	2.86
Johnson		1.81	1.17
Sandy		0.98	0.77

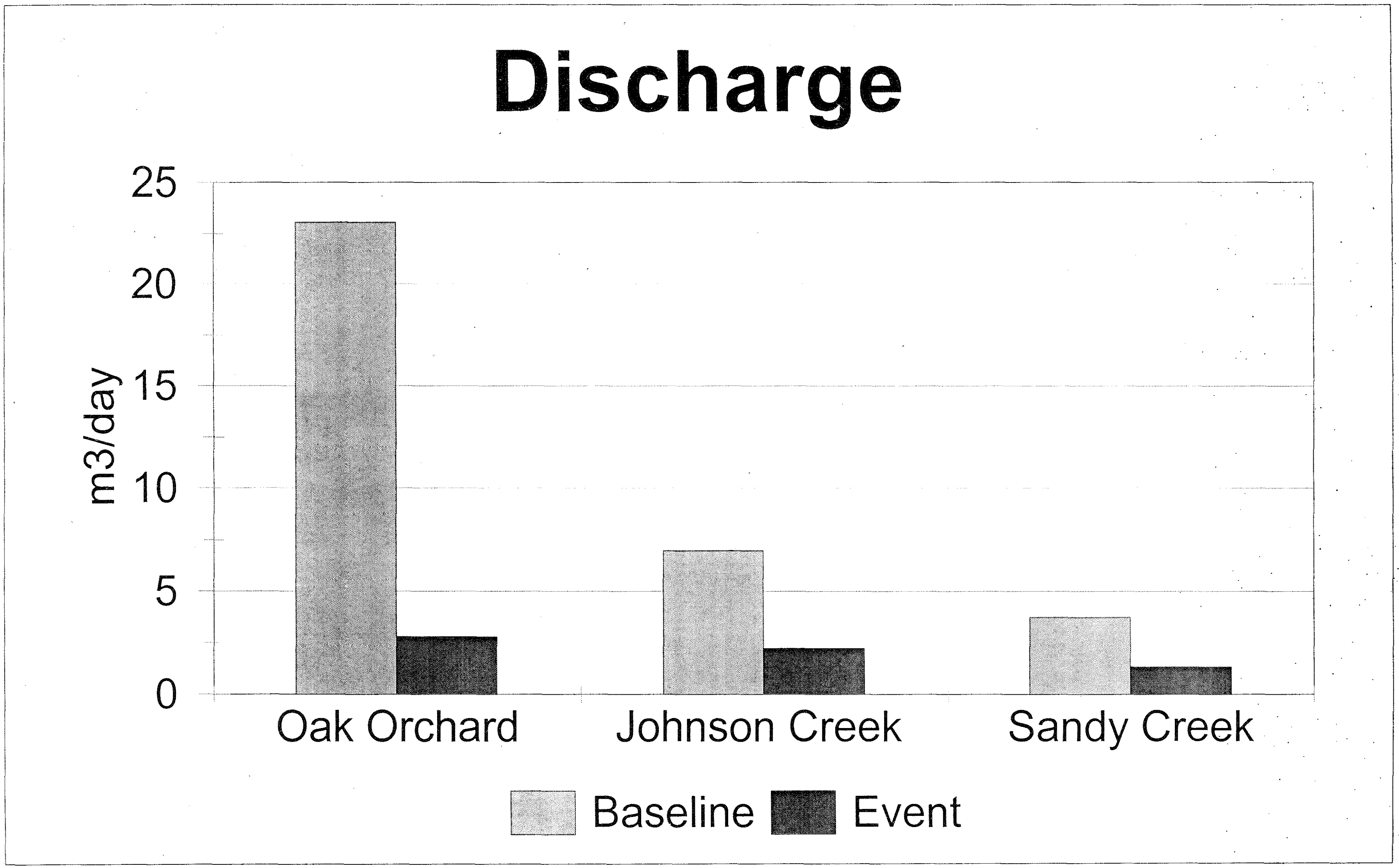


Figure 1. Average daily baseline and event discharge from Oak Orchard, Johnson and Sandy Creeks for the period 1 June 1998 to 31 May 1999.

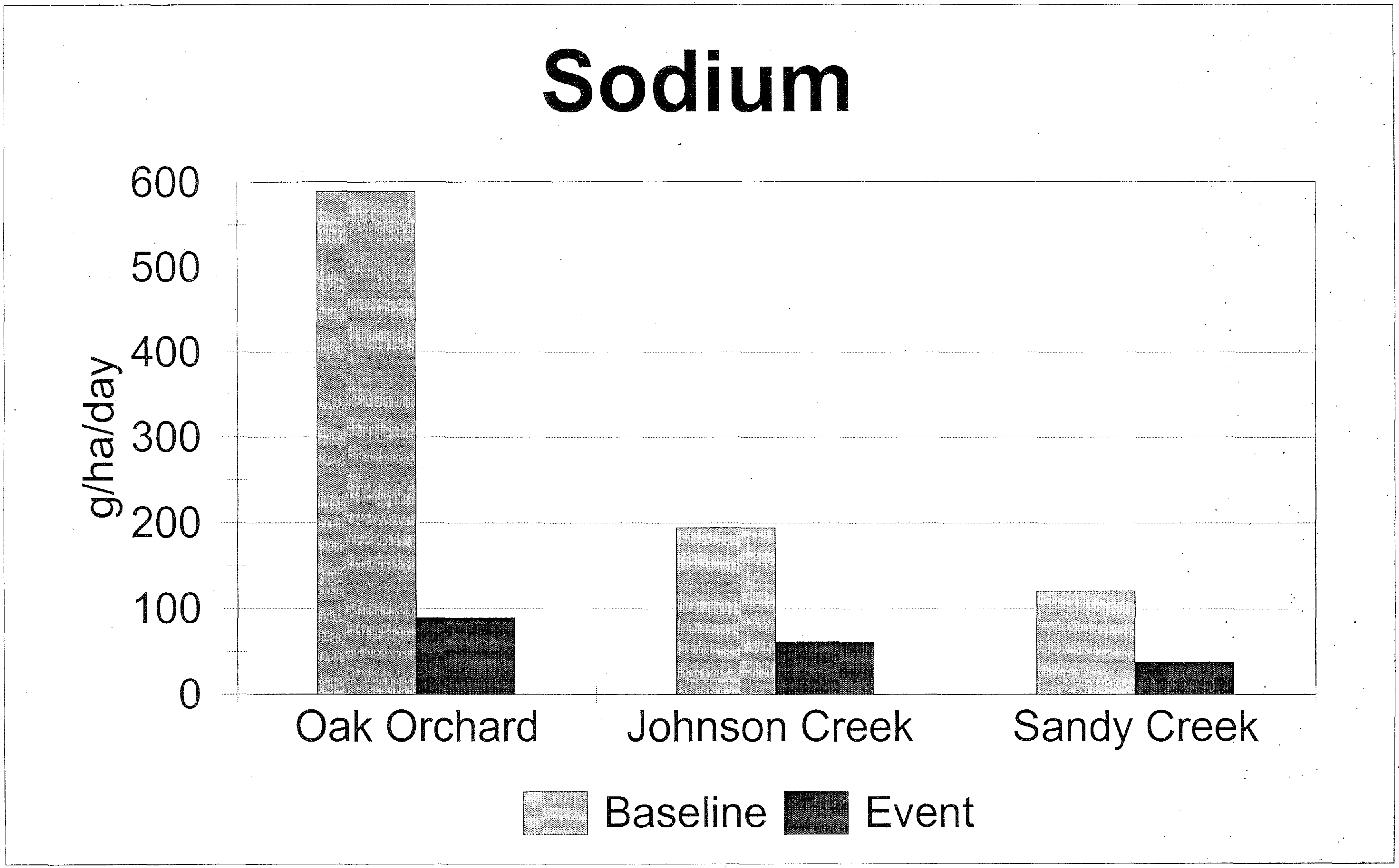


Figure 2. Average daily baseline and event sodium loss from Oak Orchard, Johnson and Sandy Creeks for the period 1 June 1998 to 31 May 1999.

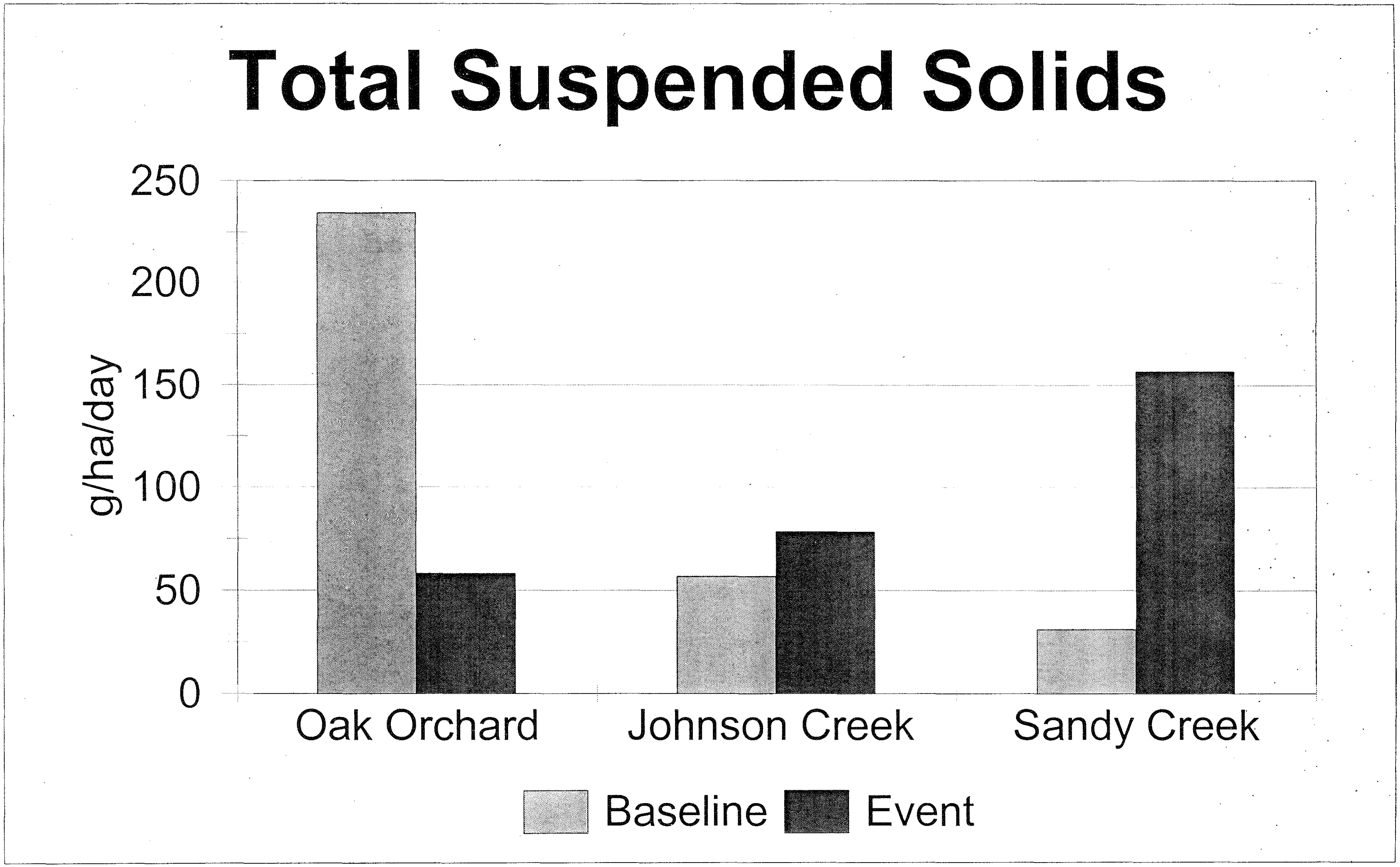


Figure 3. Average daily baseline and event total suspended solids loss from Oak Orchard, Johnson and Sandy Creeks for the period 1 June 1998 to 31 May 1999.

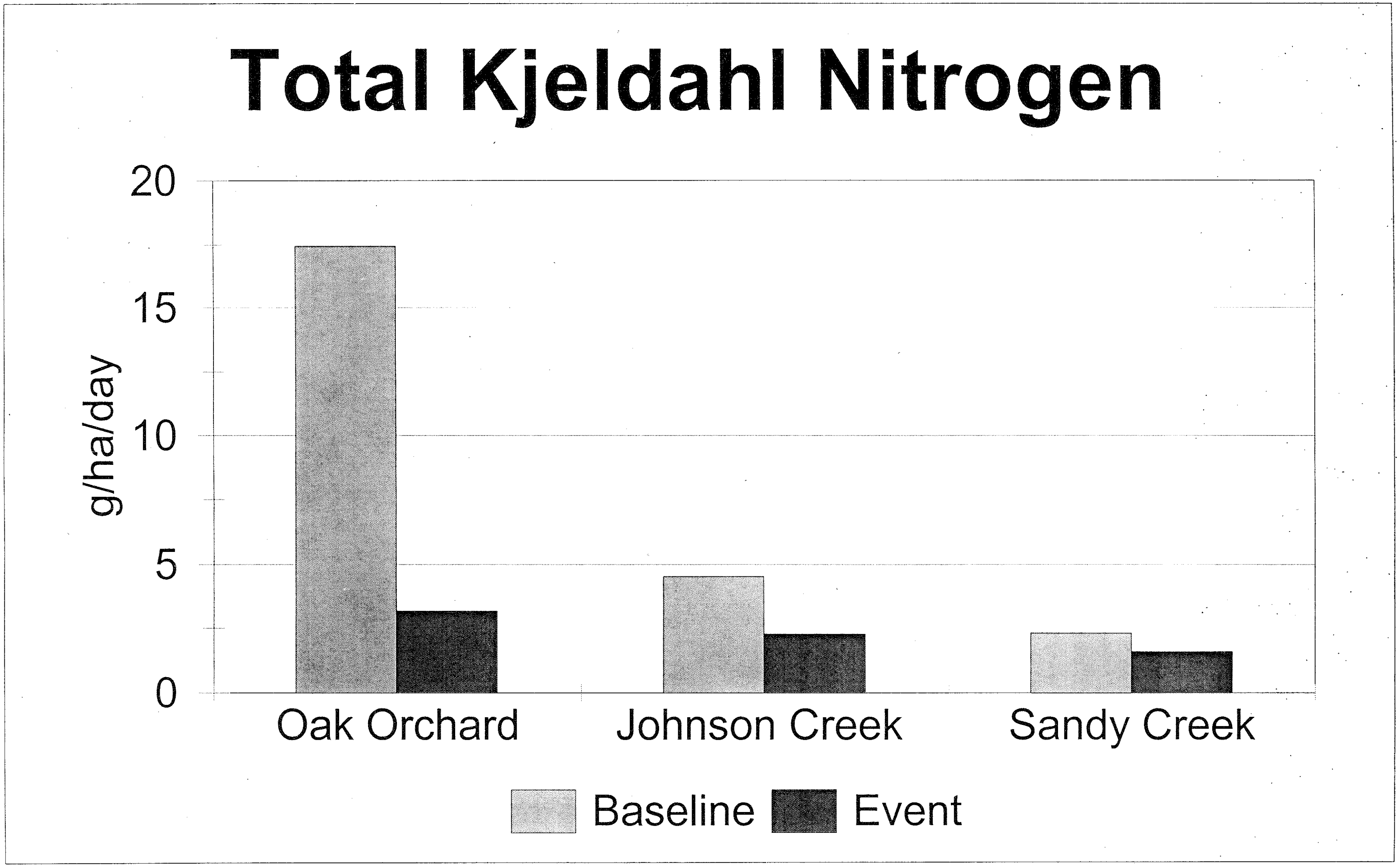


Figure 4. Average daily baseline and event total Kjeldahl nitrogen loss from Oak Orchard, Johnson and Sandy Creeks for the 1 June 1998 to 31 May 1999.

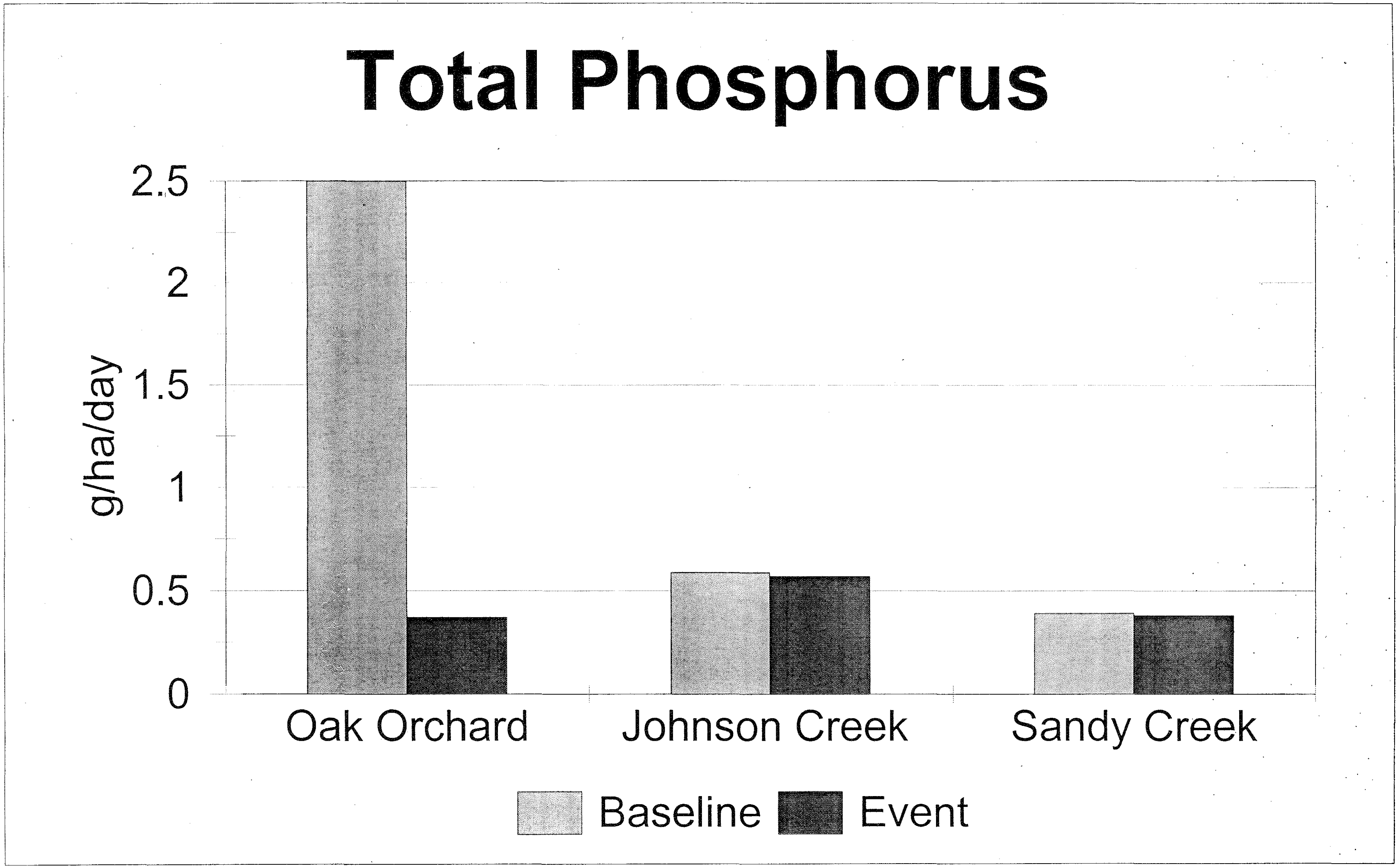


Figure 5. Average daily baseline and event total phosphorus loss from Oak Orchard, Johnson and Sandy Creeks for the period 1 June 1998 to 31 May 1999.

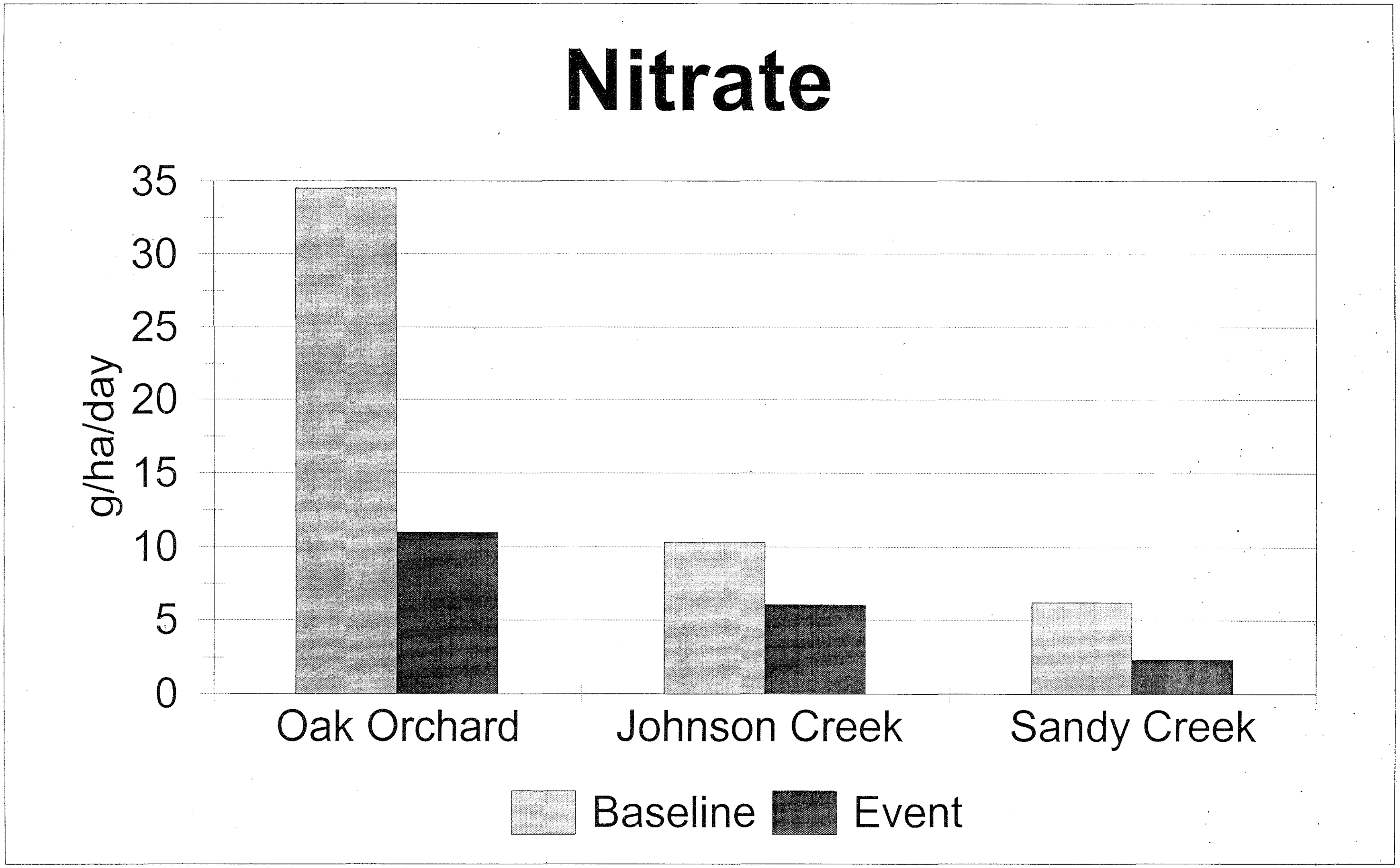
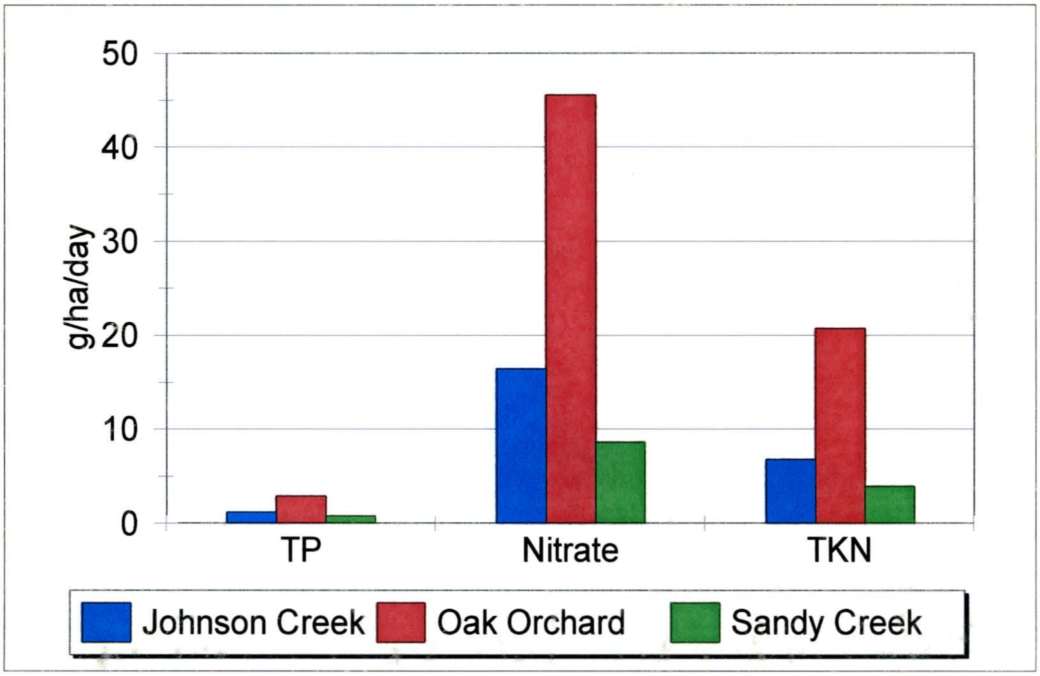


Figure 6. Average daily baseline and event nitrate loss from Oak Orchard, Johnson and Sandy Creeks for the period 1 June 1998 to 31 May 1999.



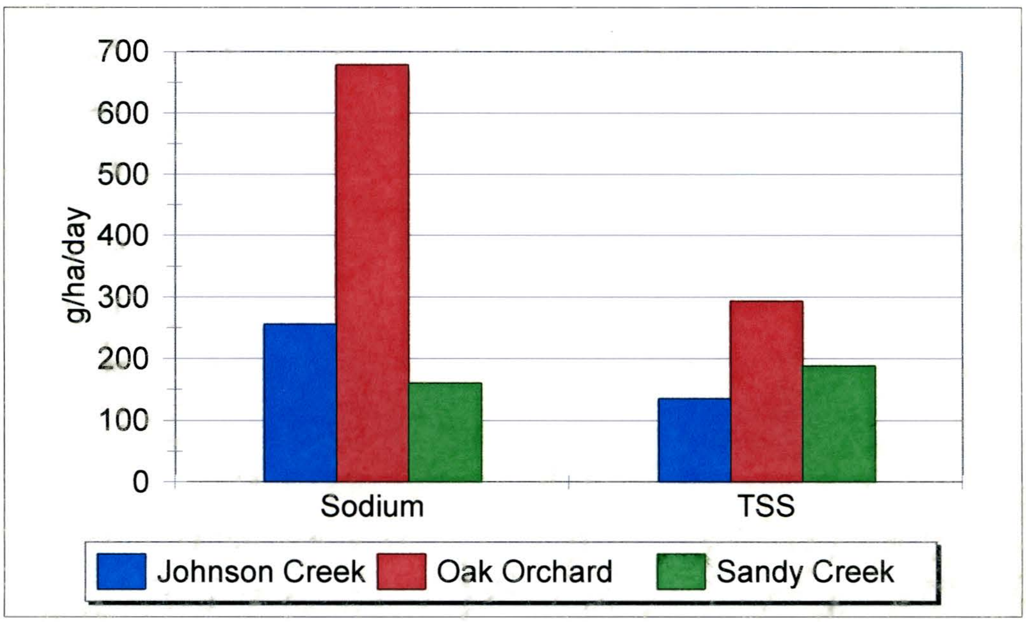
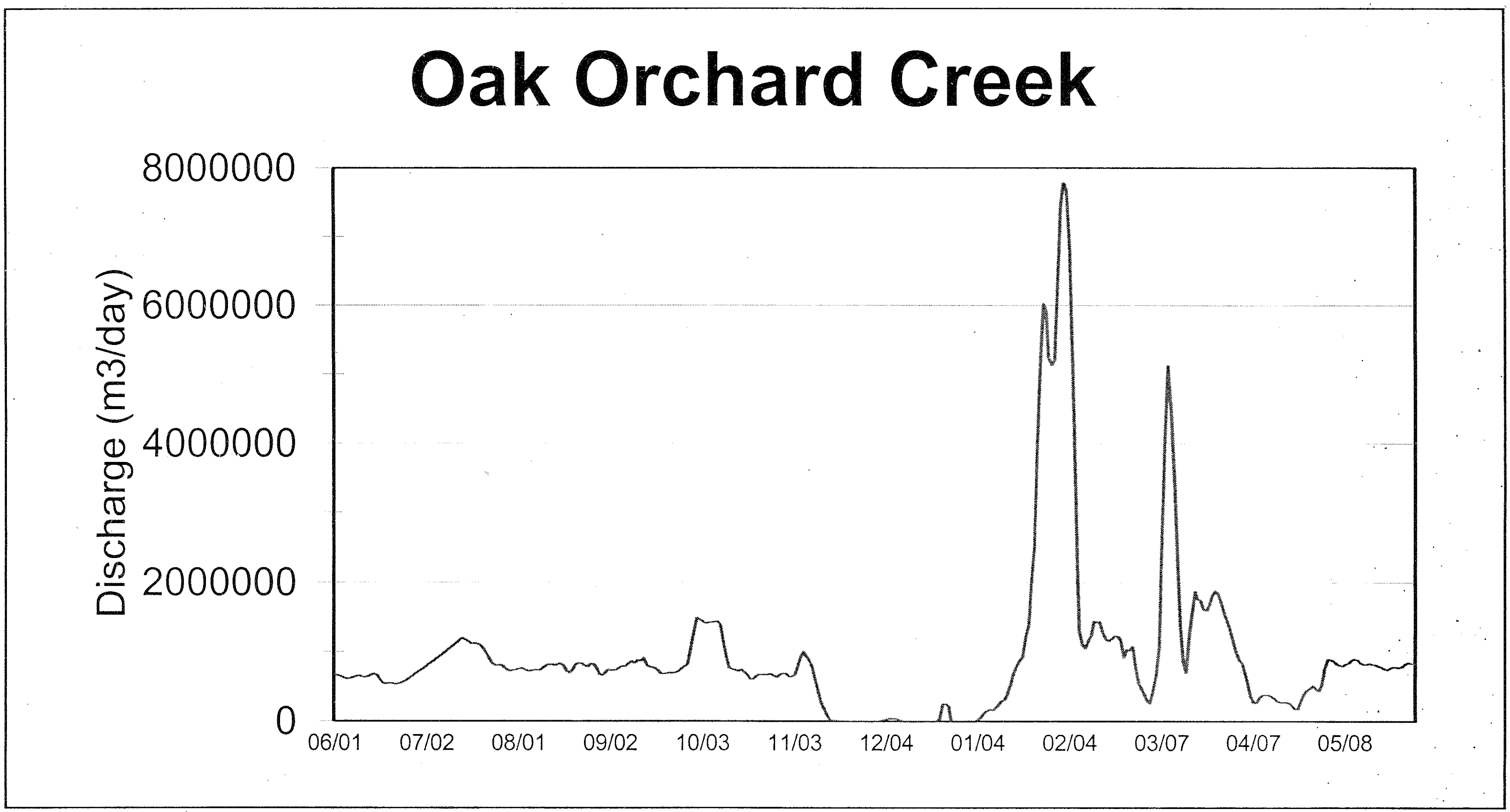
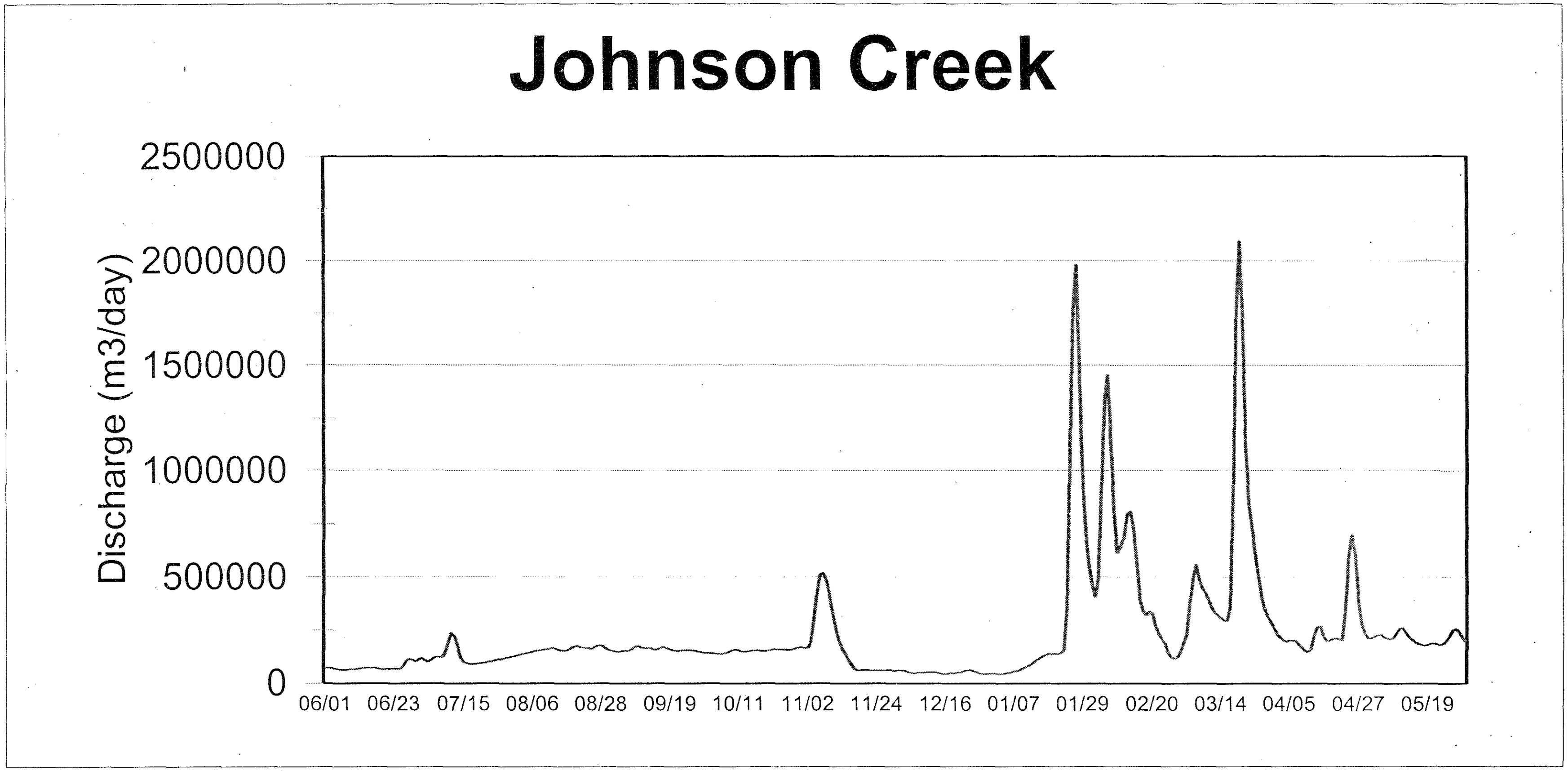


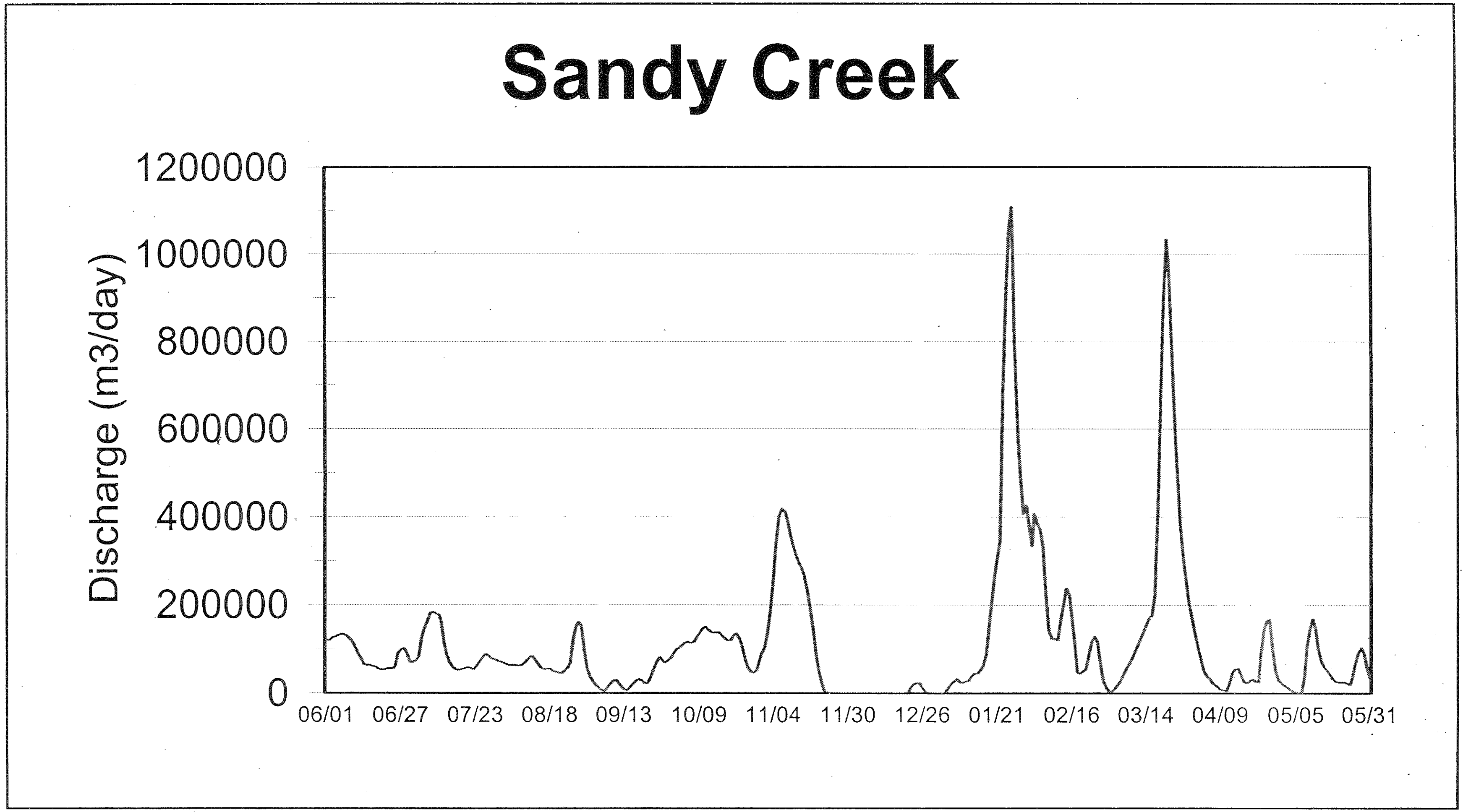
Figure 7. Areal loss of selected parameters from Oak Orchard, Johnson and the Sandy Creek watersheds for the period 1 June 1998 to May 31 1999. TP = total phosphorus, TKN = total Kjeldahl nitrogen, TSS = total suspended solids.



Appendix 1. Discharge for Oak Orchard Creek for the period 1 June 1998 to 31 May 1999 recorded at the automated monitoring station located on Town Line Road.



Appendix 2. Discharge for Johnson Creek for the period 1 June 1998 to 31 May 1999 recorded at the automated monitoring station located on Harris Road.



Appendix 3. Discharge for Sandy Creek for the period 1 June 1998 to 31 May 1999 recorded at the automated monitoring station located on Norway Road.